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Reasons Why Geomagnetic Field Generation is Physically Impossible in Earth's Fluid Core

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ABSTRACT

Despite the importance for understanding the nature of the geomagnetic field, and especially its potential for radically disrupting modern civilization [1], virtually all scientific publications relating to it are based upon the false assumption that the geomagnetic field is generated in the Earth's fluid core. By adhering to an outmoded paradigm, members of the geoscience community have potentially exposed humanity to globally devastating risks, leaving it unprepared for an inevitable geomagnetic field collapse. There is no scientific reason to believe that the geomagnetic field is generated within the fluid core. Convection is physically impossible in the fluid core due to its compression by the weight above and its inability to sustain an adverse temperature gradient. There is no evidence of ongoing inner core growth to provide energy to drive thermal convection or to cause compositional convection. Moreover, there is no mechanism to account for magnetic reversals and no means for magnetic seed-field production within the fluid core to initiate dynamo amplification. Earth's nuclear georeactor, seat of the geomagnetic field, has none of the problems inherent in putative fluid-core geomagnetic field production. With a mass of about one ten-millionth that of the fluid core, georeactor sub-shell convection can potentially be disrupted by great planetary trauma, such as an asteroid impact, or by major solar outbursts or even by human activities, for example, by deliberate electromagnetic disturbance of the near-Earth environment, including the Van Allen belts. Furthermore, sub-shell convection disruption might trigger surface geophysical disasters, such as super-volcano eruptions [2-4]. Scientists have a fundamental responsibility to tell the truth and to provide scientific understanding that benefits humanity.

Keywords: Corona ejections; Magnetic reversals; Geomagnetic storms; Geomagnetic collapse; Solar wind; Super volcano; Communications disruption; Inner core; Convection.

INTRODUCTION

Albert Einstein [5] worked diligently, but unsuccessfully, to understand the origin of Earth's magnetic field, which he considered to be one of the five most important unsolved problems in physics [6].

Although the magnetic compass was used in antiquity [7], the cause of its operation, now referred to as the Earth's magnetic field or geomagnetic field, was a great mystery. For centuries, it was not known whether that magnetic field originated within the Earth or was extra-terrestrial in origin. In 1600, William Gilbert [8] showed that magnetic compass deflections measured around a sphere fabricated from magnetic loadstone corresponded to compass deflections recorded by navigators around the surface of our planet. In 1838, Carl Friedrich Gauss [9] showed mathematically that the seat of the geomagnetic field resides at or near Earth's center.

In 1855, Michael Faraday [10] reported his discovery that an electric current, i.e., the flow of electric charges, produces a magnetic field. Earth's fluid core, discovered in 1906 [11], was the only interior region thought to be capable of motion in addition to planetary rotation, until 1993 [12]. Walter Elsasser [13] in 1939 suggested that the geomagnetic field might be produced by convection in Earth's fluid core, which, coupled with planetary rotation, acts as a dynamo, a magnetic amplifier. Elsasser [13-15] simply assumed that convection exists in the fluid core without any independent corroborating evidence. More than 80 years later no independent corroborating evidence has been discovered.

Life on Earth depends critically on the geomagnetic field, which deflects away the harmful solar wind (Figure 1). From time to time, massive pulses of charged plasma are ejected from the sun's corona [16], and partially overwhelm Earth's geomagnetic field, producing infrastructure-damaging geomagnetic storms that disrupt communications and navigation systems, and damage electrical equipment by induced electric currents [17, 18]. These already produced events prefigure what is to come at some unknown time in the future. With the inevitable next collapse of the geomagnetic field, the charged-particle onslaught from the sun will devastate our infrastructure, potentially wiping out two centuries of steady technological development overnight [1].

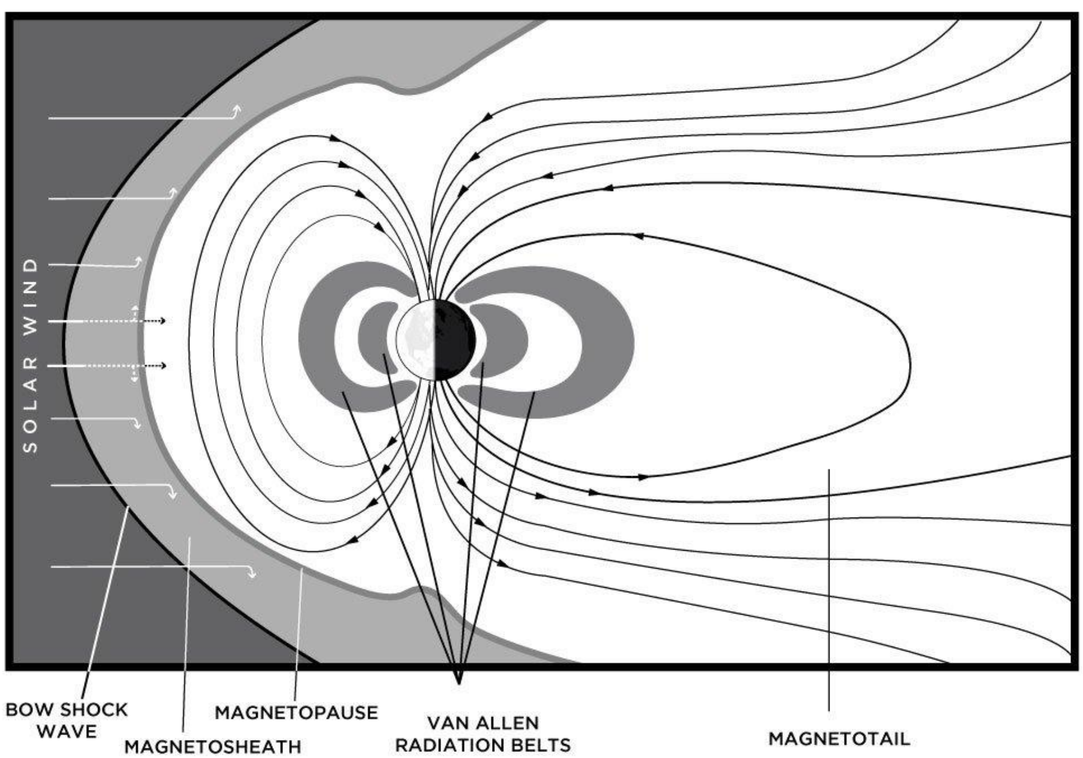

Figure 1. Schematic representation of the geomagnetic shield. From [19].

Understanding the true nature of Earth's magnetic field, I submit, should be an extremely high priority for geoscientists, but it is not. Elsasser's hypothesis stands despite its inherent unexplored difficulties. Published evidence that contradicts Elsasser's fluid-core dynamo concept is ignored. The consequences of such scientific malpractice pose undue risks to humanity, leaving it unprepared for an inevitable collapse of the geomagnetic field.

Geoscientists should ask the question: "What is wrong with this picture?" – Specifically the picture posed by Elsasser's hypothesis.

In the following I describe what is wrong with the concept of geomagnetic field production in Earth's fluid core. Then I briefly review evidence, published in the scientific literature [2-4, 12, 20-28], of a fundamentally different origin of Earth's internally-produced magnetic field, which is applicable not only to Earth, but also to other planets and large moons.

UNDERSTANDING THERMAL CONVECTION

Elsasser's fluid-core dynamo concept depends critically upon the existence of convection in the liquid iron-alloy that comprises nearly one-third of Earth's mass. Convection is a readily visualized process. Heat a pot of water on the stovetop. Add tea leaves or celery seeds to observe motion of the water. Before the water starts to boil, bottom-to-top and top-to-bottom circulation occurs. This motion is convection.

Convection is perhaps the most misunderstood natural process in Earth science. Hypothetical, computer-programmed convection models of Earth's fluid core [29-32] continue to be produced, although sustained fluid-core thermal convection has been shown to be physically impossible [33] and therefore necessitates a fundamentally different geoscience paradigm [2-4, 12, 20-28].

In 1957, Subrahmanyan Chandrasekhar [34] described convection in the following, easy-to-understand way: *The simplest example of thermally induced convection arises when a horizontal layer of fluid is heated from below and an adverse temperature gradient is maintained* [i.e., bottom hotter than top]. *The adjective 'adverse' is used to qualify the prevailing temperature gradient, since, on account of thermal expansion, the fluid at the bottom becomes lighter than the fluid at the top; and this is a top-heavy arrangement which is potentially unstable. Under these circumstances the fluid will try to redistribute itself to redress this weakness in its arrangement. This is how thermal convection originates: It represents the efforts of the fluid to restore to itself some degree of stability.*

Consider the example of a pot of water on the stovetop. Heat at the bottom causes the water to be slightly less heavy (less dense) than the water above. This is an unstable configuration. The heavier (more dense) water at the top falls by gravity displacing the lighter (less dense) water at the bottom. The *adverse temperature gradient*, *i.e.* the bottom being hotter than the top, is maintained by the cooling that occurs at the open water surface.

To the best of my knowledge, consequences of the *adverse temperature gradient*, described by Chandrasekhar [34] have not been explicitly considered in either solid-Earth or tropospheric convection calculations. Despite lengthy literature searches, I was unable to find quantification of the effect of adverse temperature gradient on convection efficiency. The following simple classroom-demonstration experiment, however, can provide critical insight for understanding how convection works and is applicable to a proper understanding of Earth-core convection [33], as well as to tropospheric convection in Earth's atmosphere [35].

As described recently [36]: *The convection classroom-demonstration experiment was conducted using a 4 liter beaked-beaker, nearly filled with distilled water to which celery seeds were added, and heated on a regulated hot plate. The celery seeds, dragged along by convective motions in the water, served as an indicator of convection. When stable convection was attained, a ceramic tile was placed atop the beaker to retard heat loss, thereby increasing the temperature at the top relative to that at the bottom, thus decreasing the adverse temperature gradient.*

Figure 2, from [35], extracted from the video record [37, 38], shows dramatic reduction in convection after placing the tile atop the beaker. In only 60 seconds the number of celery seeds in motion, driven by convection, decreased markedly, demonstrating the principle that reducing the adverse temperature gradient decreases convection. That result is reasonable as zero adverse temperature gradient by definition is zero thermal convection.

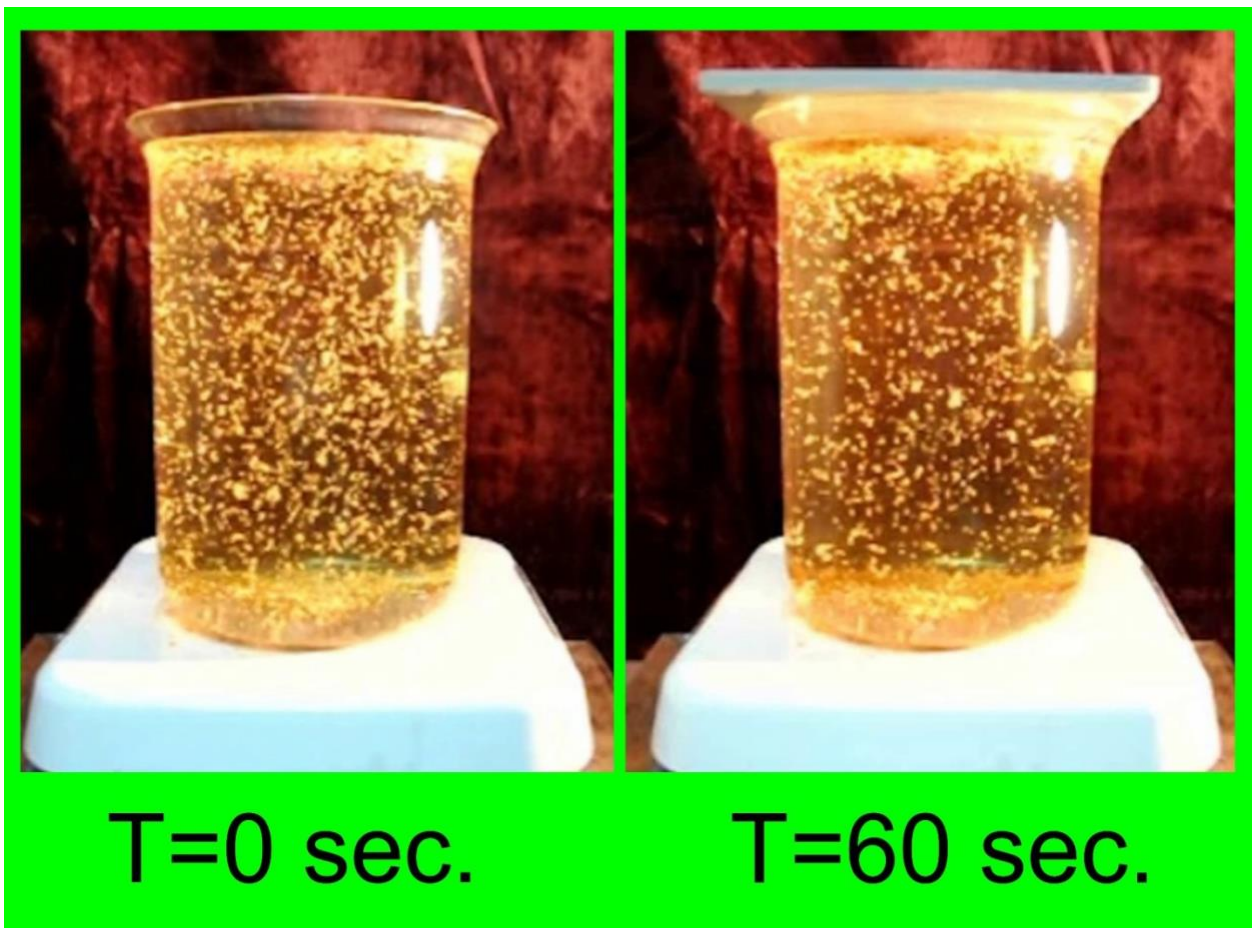

Figure 2. From [35]. A beaked-beaker of water on a regulated hot plate with celery seeds pulled along by the fluid convection motions. Placing a ceramic tile atop the beaker a moment after T=0 reduced heat-loss, effectively warming the upper solution's temperature, thus lowering the adverse temperature gradient, and reducing convection, indicated by the decreased number of celery seeds in motion at T=60 sec.

COUNTER ARGUMENTS TO GEOMAGNETIC FIELD GENERATION IN EARTH'S FLUID CORE

Counter Argument 1: If the Earth's fluid core were heated at the bottom, the heat would be rapidly transferred to the core-top, heating that region, reducing the *adverse temperature gradient*. To maintain convection in the fluid core, heat must be removed from the surface at virtually the same rate it is brought from the bottom of the fluid core. However, that is physically impossible because the fluid core is surrounded by a thermally insulating blanket, the mantle, which has lower thermal conductivity, lower heat capacity, and greater viscosity than the fluid core [33].

Counter Argument 2: Due to compression by the weight above, the density at the bottom of the fluid core is 23% greater than the density at core-top [39] as shown in Figure 3. Decrease in density at core-bottom by thermal expansion (<1%) cannot make the core-top heavier than the core-bottom, *i.e.*, cannot make the fluid core unstable, the condition for thermal convection according to Chandrasekhar [34].

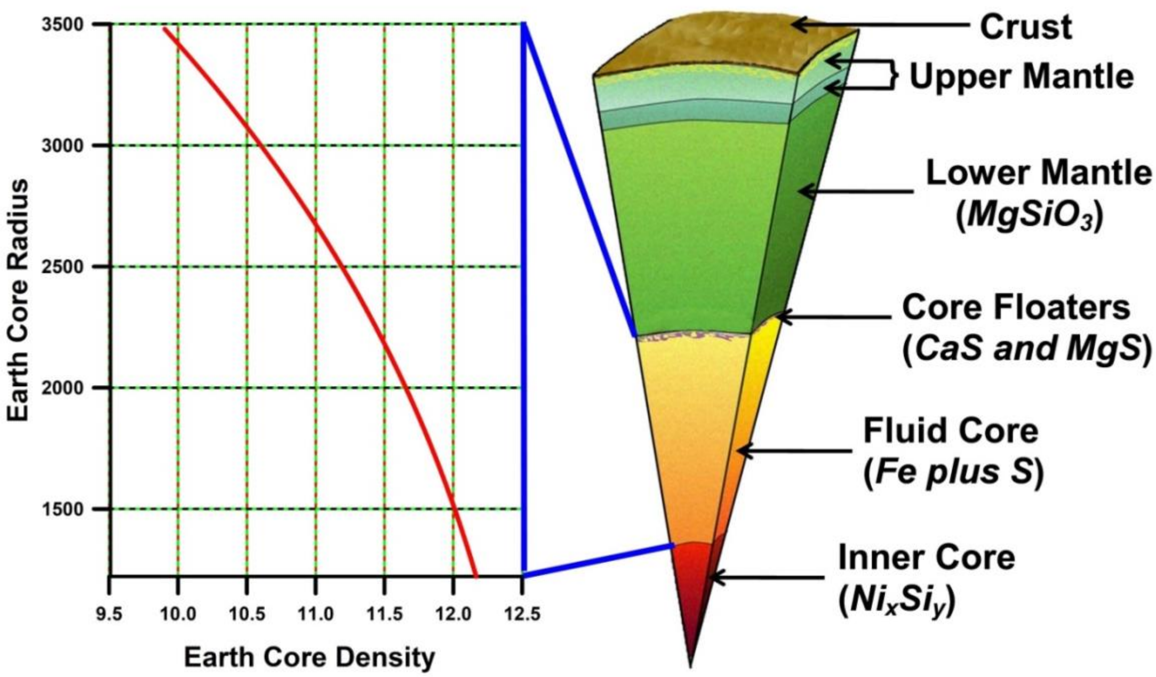

Figure 3. Major portions of the Earth's interior and the fluid-core density variation (in g/cm³) as a function of radius (in km).

Counter Argument 3: Calculation of a high Rayleigh Number from Earth-core parameters is *not* indicative of convective instability, as is widely believed. The Rayleigh Number was derived for a thin film (typically less than 1 mm in thickness) based upon assumptions that are inconsistent with the physical parameters of Earth's fluid core, namely, the core being "*incompressible*", density being "*constant*" except as modified by thermal expansion, and pressure being "*unimportant*" (quotes from Lord Rayleigh [40]).

Counter Argument 4: A dynamo is a magnetic amplifier and requires an ambient magnetic field to initiate amplification. In Earth's fluid-core there is no obvious source of magnetic seed-fields to initially amplify.

Counter Argument 5: Despite more than 80 years of scientific investigation, no viable mechanism has been discovered in the Earth's fluid core that could account in a logical, causally related manner for the numerous geomagnetic reversals and excursions that have been documented throughout geologic time (Figure 4).

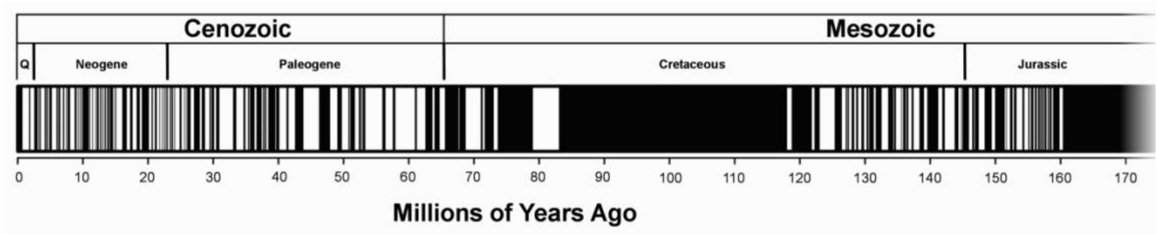

Figure 4. Geomagnetic polarity since the middle Jurassic. Dark areas denote periods where the polarity matches today's polarity, while light areas denote periods where that polarity is reversed. Based upon published data [41, 42]. Reproduced from [2].

Counter Argument 6: There is no energy source within the fluid core to sustain convection. Geoscientists who believe the geomagnetic field is produced by convection in the Earth's fluid core invariably promote the idea that the inner core consists of partially crystallized iron metal. Based upon that 1940 [43] idea and without corroborating evidence, they assume that the inner core is growing and its growth powers both thermal and compositional convection.

To explain Inge Lehmann's discovery of Earth's inner core [44], Francis Birch [43], believing the core was like the iron metal of ordinary chondrite meteorites, assumed the inner core is iron in the process of crystallizing. Evidence necessary for a different understanding was not available until the 1960s and early 1970s [45-47]. In 1979 while investigating enstatite chondrites, I [48] published the fundamentally new concept that the inner core is fully crystallized nickel silicide (Figure 5).

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The nickel silicide inner core of the Earth

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From observations of nature the suggestion is made that the inner core of the Earth consists not of nickel–iron metal but of nickel silicide.

Contemporary understanding of the physical state and chemical composition of the interior of the Earth is derived primarily from interpretations of seismological measurements and from inferences drawn from observations of meteorites. Seismological investigations by Oldham (1906), Gutenberg (1914) and others helped to establish the idea that a fluid core extends to approximately one half the radius of the Earth. The existence of a small, apparently solid inner core at the centre of the Earth was recognized by Lehmann (1936) from interpretations of

Figure 5. From [48].

I subsequently published fundamental mass ratio relationships demonstrating that Earth's core and lower mantle resemble corresponding portions of an enstatite chondrite, not an ordinary chondrite [12, 21-23, 25-28, 33, 49-52], as shown in Table 1. For details see [33].

Table 1. Comparison of fundamental Earth mass ratios with corresponding ratios for the Abee enstatite chondrite

Fundamental Earth Ratio	Earth Ratio Value	Abee e.c. Ratio Value
Lower Mantle Mass to Total Core Mass	1.49	1.43
Inner Core Mass to Total Core Mass	0.052	theoretical 0.052 if Ni_3Si 0.057 if Ni_2Si
Inner Core Mass to Lower Mantle + Total Core Mass	0.021	0.021
D" CaS + MgS Mass to Total Core Mass	0.09	.011
ULVZ of D" CaS Mass to Total Core Mass	0.012	0.012

Formation under highly reducing conditions [53, 54] led to the alloy portions of certain enstatite chondrites and planetary cores containing some calcium, magnesium, and silicon, and a large proportion of uranium [55]. Being incompatible in an iron-based alloy, these elements precipitated and formed the components of Earth's core, distributed on the basis of density, including a central concentration of uranium that formed what I called the *georeactor* [12, 21, 22, 25-28, 52, 56] (Figure 6).

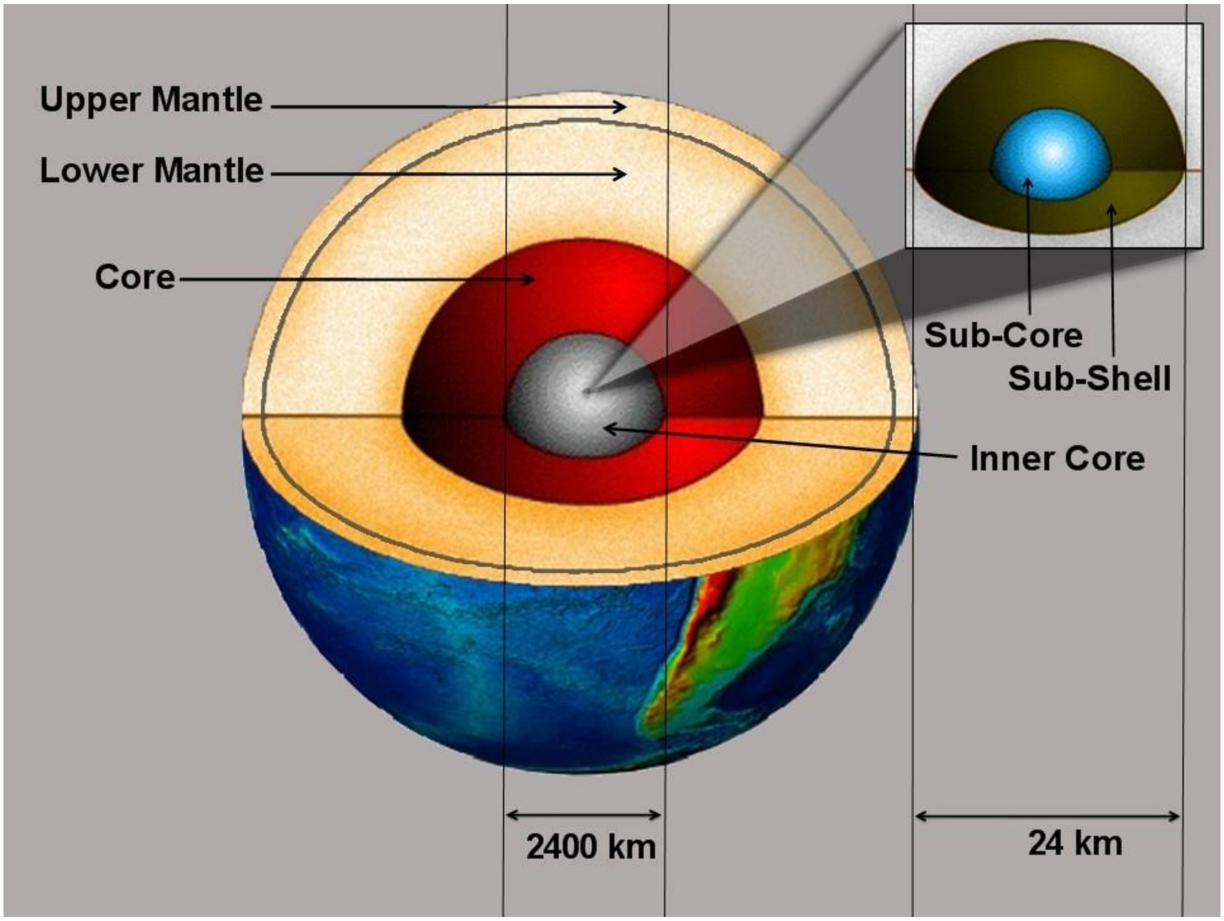

Figure 6. Schematic representation of the georeactor, a natural planetocentric nuclear fission reactor [26, 28].

PLANETOCENTRIC GEOREACTOR MAGNETIC FIELD GENERATION

In a series of publications beginning in 1993 [12, 21, 22, 25, 26, 56, 57], I demonstrated the feasibility that an accumulation of uranium at Earth's center maintains a self-sustaining nuclear fission chain reaction. The *georeactor*, as it came to be known, provides both the energy source for geomagnetic field generation, and a location, not in the fluid core (Figure 5), but in the georeactor itself, wherein it can generate the geomagnetic field by Elsasser's [13-15] dynamo mechanism.

In a review article, published in 2014 [28], I described with specificity the background, basis, feasibility, structure, evidence, and geophysical implications of a naturally occurring Terracentric nuclear fission georeactor. For a nuclear fission reactor to exist at the center of the Earth, all of the following conditions that must be met are met:

- Originally there was a substantial quantity of uranium within Earth's core.
- There is a natural mechanism for concentrating the uranium at the Earth's center.
- The isotopic composition of the uranium at the onset of fission was appropriate to sustain a nuclear fission chain reaction.
- The reactor is able to breed a sufficient quantity of fissile nuclides to permit operation over the lifetime of Earth to the present.
- There is a natural mechanism for the removal of fission products.

- There is a natural mechanism for removing heat from the reactor.
- There is a natural mechanism to regulate reactor power level.
- The location at Earth's center provides containment and prevents meltdown.
- There are logical, causally related mechanisms that account for geomagnetic reversals and excursions.

There are two lines of independent scientific evidence attesting to georeactor existence, antineutrino measurements [58, 59] and the similarity between georeactor fission-product helium ratios calculated at Oak Ridge National Laboratory and helium ratios measured in volcanic samples [25].

Figure 7 is a schematic representation of the georeactor at Earth's center which consists of two components: The nuclear fission sub-core where sustained nuclear fission chain reactions take place, and the nuclear waste sub-shell where the products of radioactive decay and nuclear fission collect and mix with unconsumed uranium. This is where convection occurs and it produces the geomagnetic field by dynamo action. Charge particles from radioactive decay assure a plentiful source of magnetic seed-fields to initiate amplification. Sub-shell nuclear fission chain reactions are inhibited by neutron absorbers from the fission products. Uranium that settles out from the sub-shell in this microgravity environment forms the sub-core where nuclear fission chain reactions take place. Heat produced by the nuclear fission sub-core is transported by convection to the heat sink that is the inner core which is surrounded by a much more massive heat sink, the Earth's core. This is a self-regulating mechanism that is generally applicable to planetary nuclear fission reactors [27, 52]. Planetary rotation twists the convecting fluid or slurry to generate the geomagnetic field.

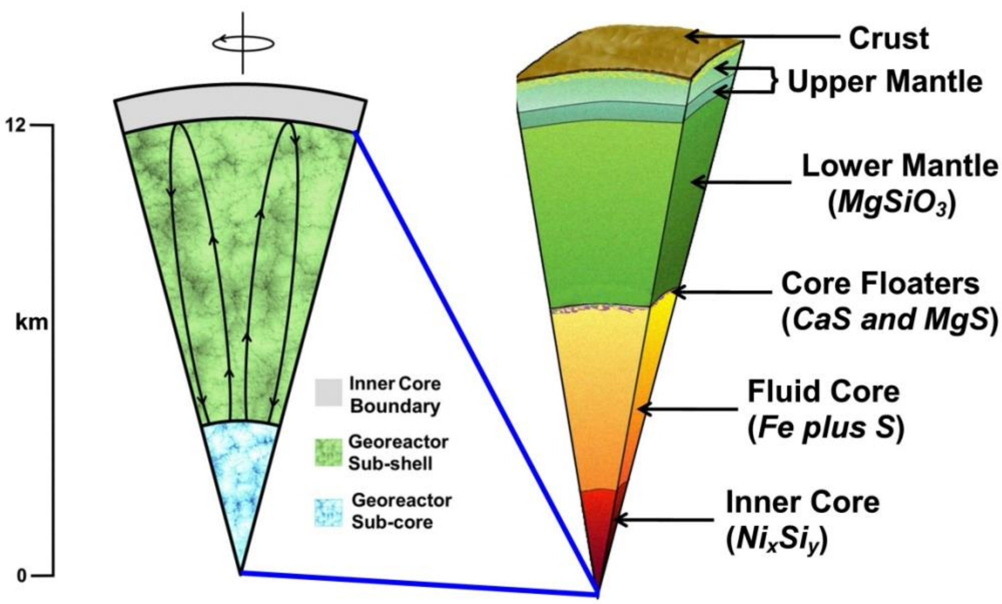

Figure 7. Schematic representation of the georeactor. Planetary rotation and fluid motions are indicated separately; their resultant motion is not shown. Stable convection with adverse temperature gradient and heat removal is expected.

CONCLUSIONS

Despite the importance for understanding the nature of the geomagnetic field, especially its potential for disruption, which could have devastating consequences for modern humanity [1], virtually all of the scientific publications relating thereto are based upon the false assumption that the geomagnetic field is generated in the Earth's fluid core. Members of the geoscience community have misrepresented the current state of knowledge in this regard and have potentially exposed humanity to globally-devastating risks, especially, being unprepared for an inevitable geomagnetic field collapse.

There is no reason to believe that the geomagnetic field is generated within the fluid core as widely believed and promulgated. Convection is physically impossible in the fluid core due to its compression by the weight above and its inability to sustain an adverse temperature gradient. There is no evidence of ongoing inner core growth that has been assumed to provide energy for thermal and compositional convection. Moreover, there is no mechanism to account for magnetic reversals and no means for magnetic seed-field production within the fluid core to initiate dynamo amplification.

Earth's nuclear georeactor, seat of its geomagnetic field, has none of the problems inherent in putative fluid-core geomagnetic field production. With a mass of about one ten-millionth that of the fluid core, georeactor sub-shell convection can potentially be disrupted by great planetary trauma, such as an asteroid impact, or by major solar outbursts or even by human activities, for example, by deliberate electromagnetic disturbance of the near-Earth environment, including the Van Allen belts. Furthermore, sub-shell convection disruption might trigger surface geophysical disasters, such as super-volcano eruptions [2-4].

Scientists have a fundamental responsibility to tell the truth and to provide scientific understanding that benefits humanity.

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